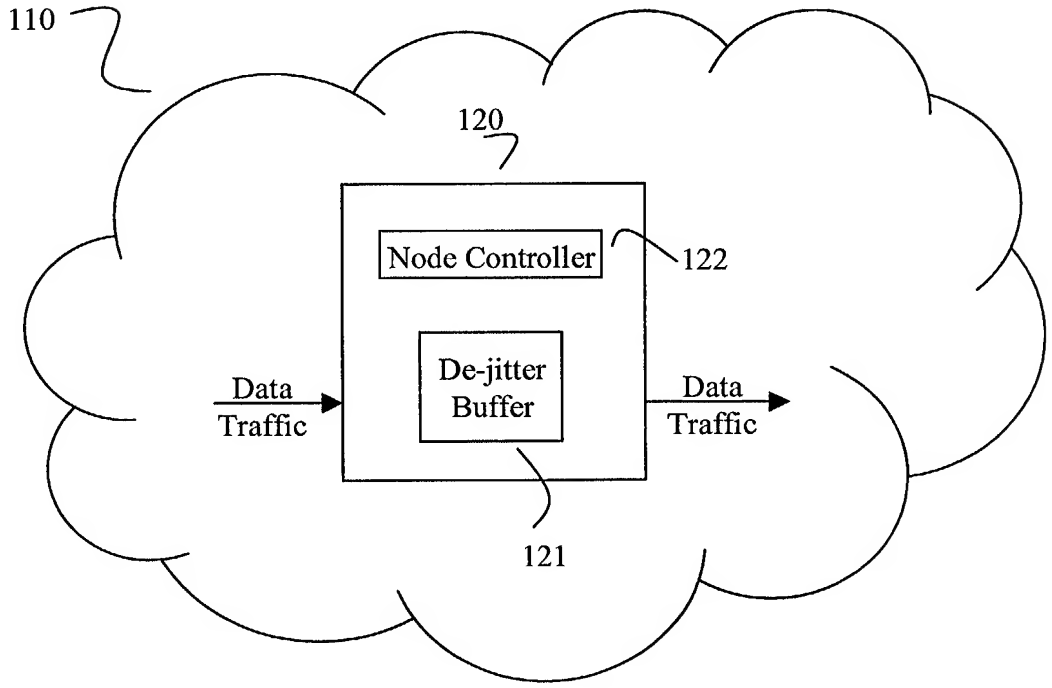
110
120
Node Controller
122
De-jitter
Buffer
Data
Traffic
Data
Traffic
121

Fig. 1

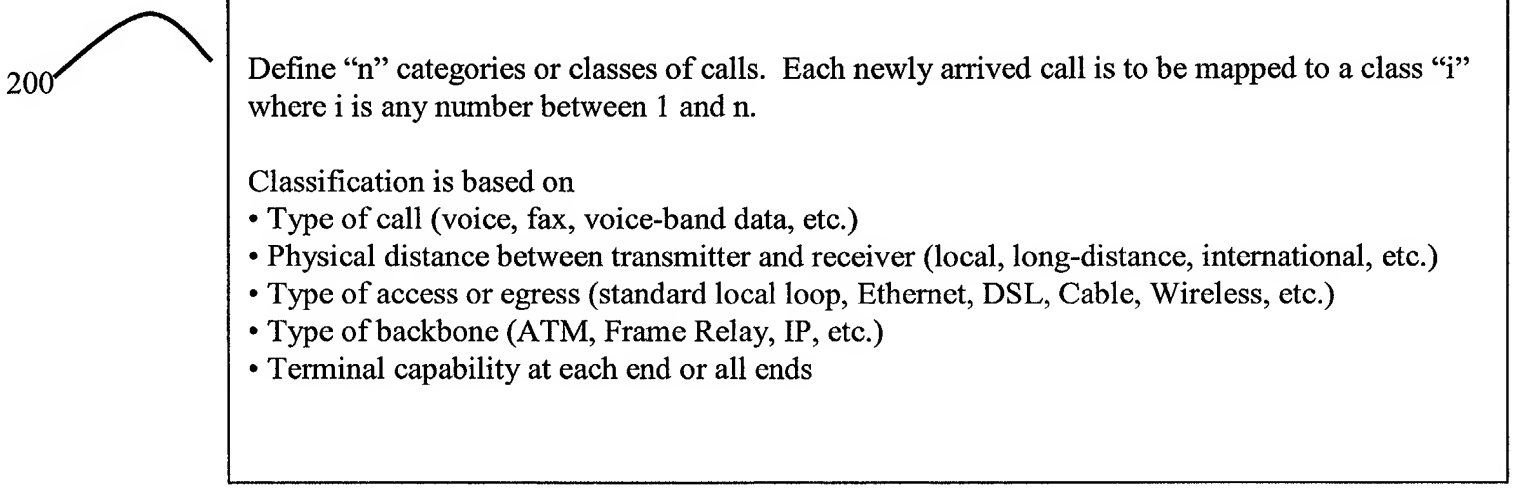
200
Define "n" categories or classes of calls. Each newly arrived call is to be mapped to a class "i" where i is any number between 1 and n.
Classification is based on
• Type of call (voice, fax, voice-band data, etc.)
• Physical distance between transmitter and receiver (local, long-distance, international, etc.)
• Type of access or egress (standard local loop, Ethernet, DSL, Cable, Wireless, etc.)
• Type of backbone (ATM, Frame Relay, IP, etc.)
• Terminal capability at each end or all ends

Figure 2

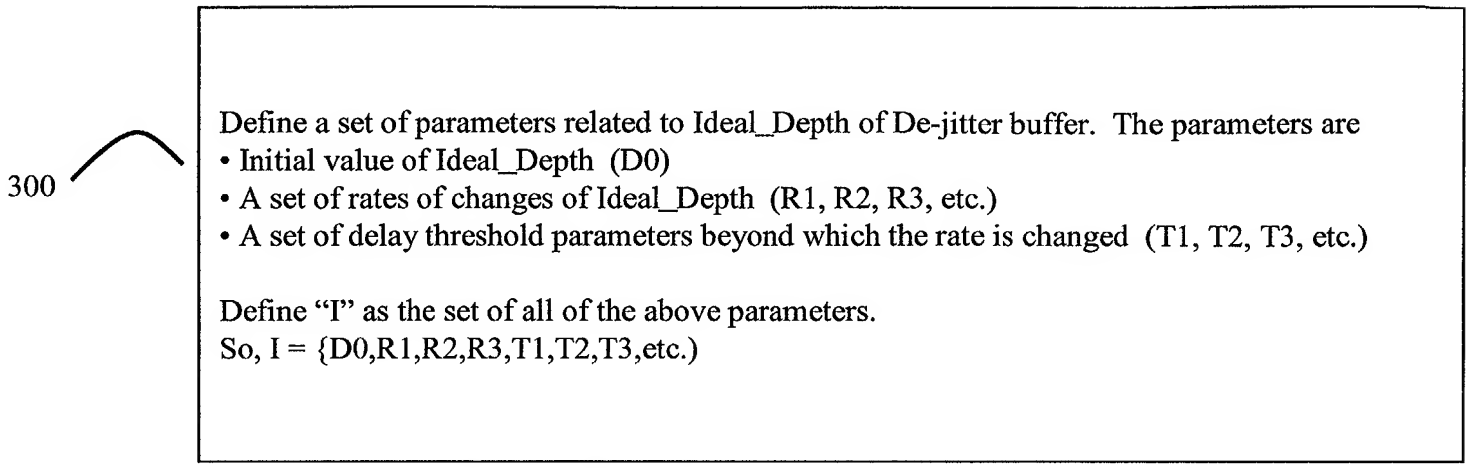
300
Define a set of parameters related to Ideal_Depth of De-jitter buffer. The parameters are
• Initial value of Ideal_Depth (D0)
• A set of rates of changes of Ideal_Depth (R1, R2, R3, etc.)
• A set of delay threshold parameters beyond which the rate is changed (T1, T2, T3, etc.)
Define "I" as the set of all of the above parameters.
So, I = {D0,R1,R2,R3,T1,T2,T3,etc.)

Figure 3

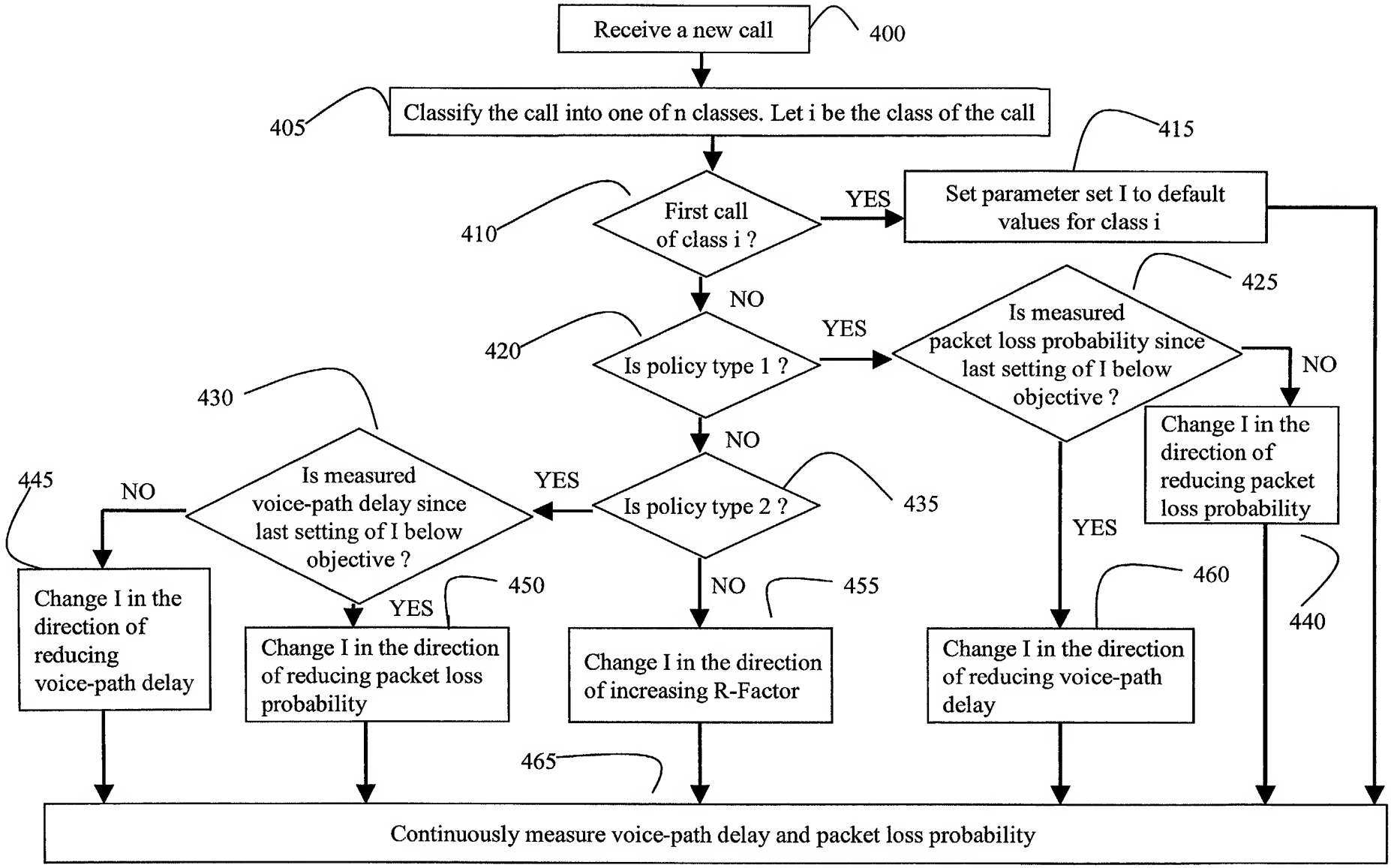
Receive a new call
400
Classify the call into one of n classes. Let i be the class of the call
405
First call of class i ?
410
YES
Set parameter set I to default values for class i
415
NO
Is policy type 1 ?
420
YES
Is measured packet loss probability since last setting of I below objective ?
425
NO
Change I in the direction of reducing packet loss probability
440
YES
Is policy type 2 ?
435
NO
Is measured voice-path delay since last setting of I below objective ?
430
YES
NO
445
Change I in the direction of reducing voice-path delay
Change I in the direction of reducing packet loss probability
450
YES
Change I in the direction of increasing R-Factor
455
NO
Change I in the direction of reducing voice-path delay
460
465
Continuously measure voice-path delay and packet loss probability

Figure 4

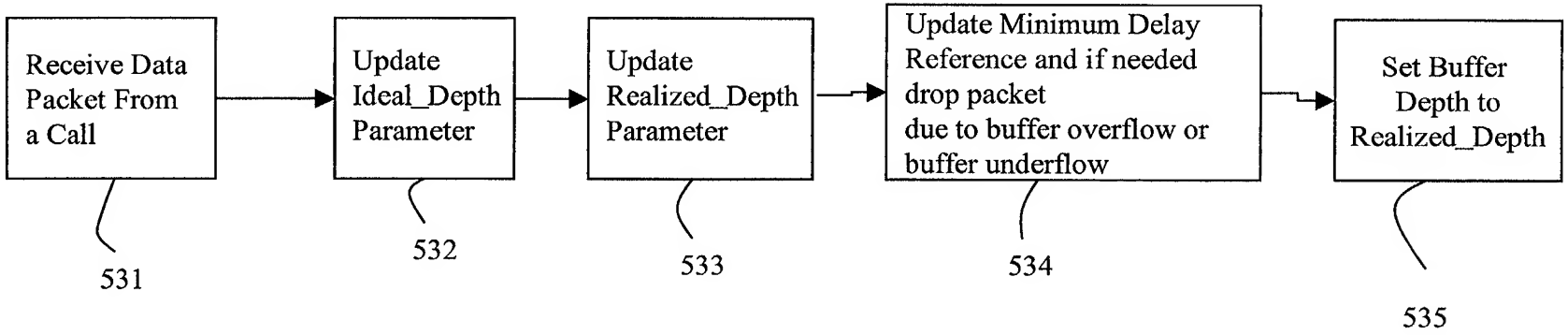
Receive Data Packet From a Call
Update Ideal_Depth Parameter
Update Realized_Depth Parameter
Update Minimum Delay Reference and if needed drop packet due to buffer overflow or buffer underflow
Set Buffer Depth to Realized_Depth
531
532
533
534
535

Fig. 5

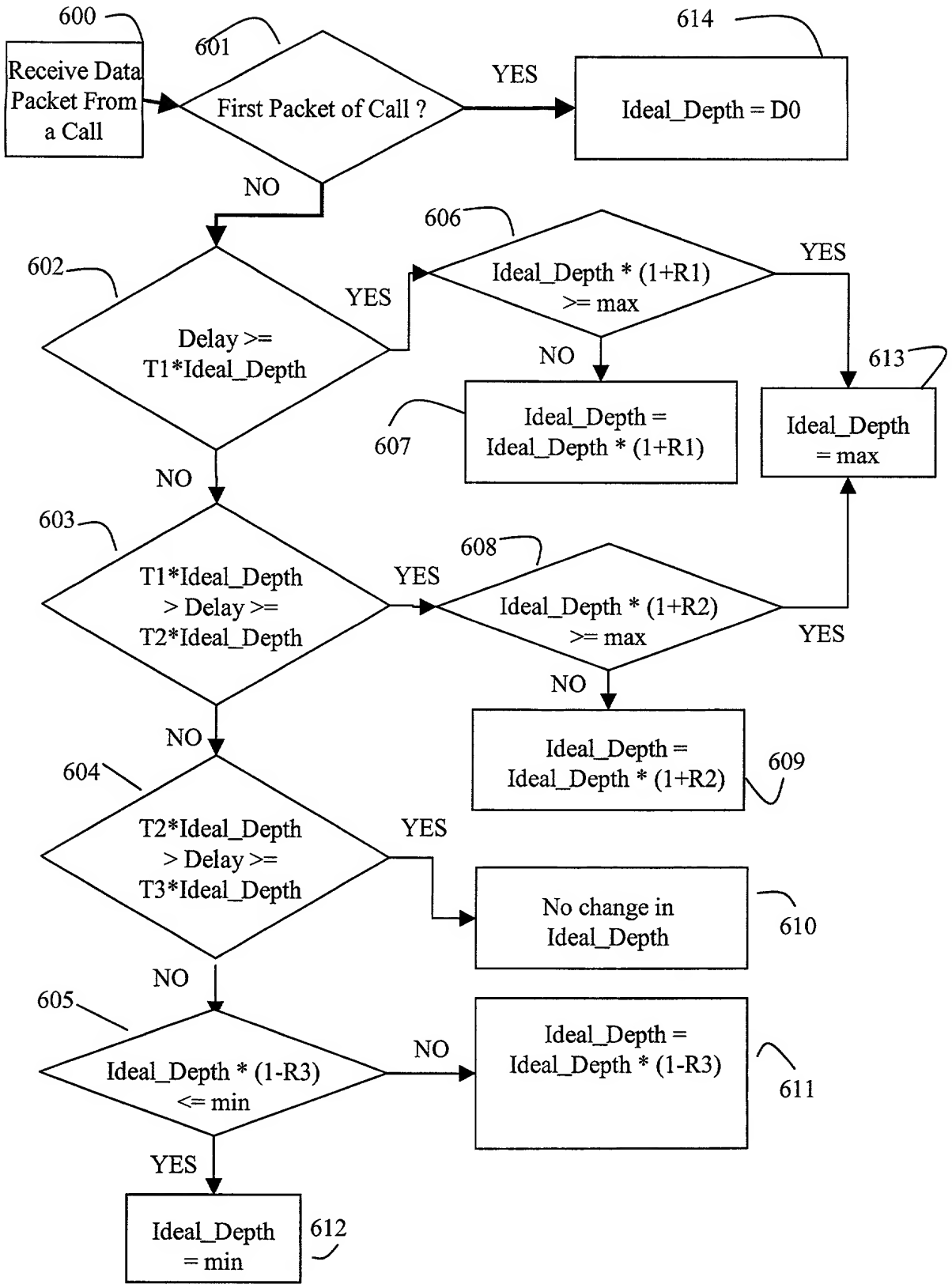
600
Receive Data Packet From a Call
601
First Packet of Call ?
YES
614
Ideal_Depth = D0
NO
602
Delay >= T1*Ideal_Depth
YES
606
Ideal_Depth * (1+R1) >= max
YES
NO
613
607
Ideal_Depth = Ideal_Depth * (1+R1)
Ideal_Depth = max
NO
603
T1*Ideal_Depth > Delay >= T2*Ideal_Depth
YES
608
Ideal_Depth * (1+R2) >= max
YES
NO
Ideal_Depth = Ideal_Depth * (1+R2)
609
NO
604
T2*Ideal_Depth > Delay >= T3*Ideal_Depth
YES
No change in Ideal_Depth
610
NO
605
Ideal_Depth * (1-R3) <= min
NO
Ideal_Depth = Ideal_Depth * (1-R3)
611
YES
Ideal_Depth = min
612

Fig. 6

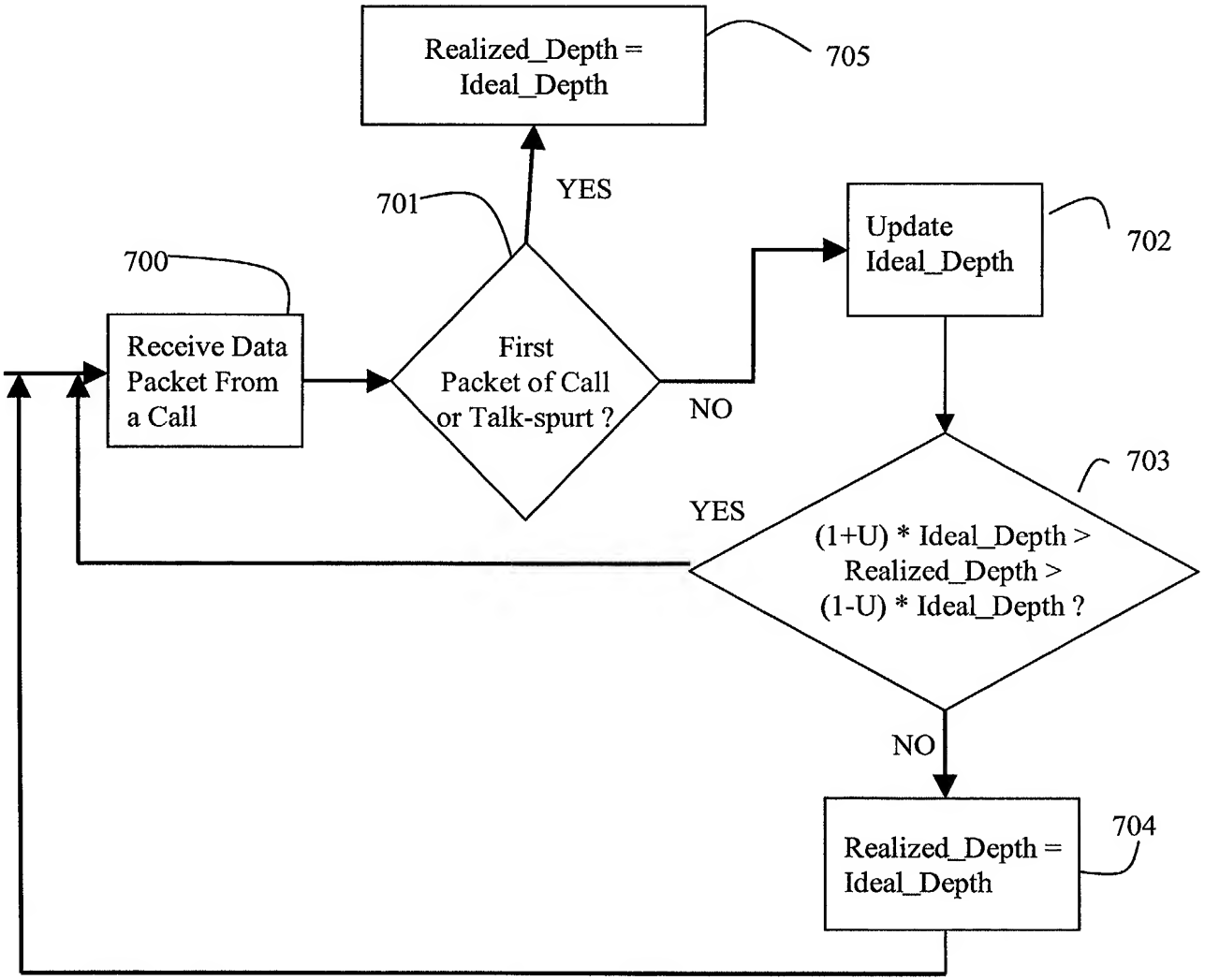
Realized_Depth = Ideal_Depth
705
YES
701
Update Ideal_Depth
702
700
Receive Data Packet From a Call
First Packet of Call or Talk-spurt ?
NO
703
YES
(1+U) * Ideal_Depth > Realized_Depth > (1-U) * Ideal_Depth ?
NO
Realized_Depth = Ideal_Depth
704

Fig. 7

800

Define the following parameters:

- t0 = arrival instant of the minimum-delay packet
- L = End-to-end delay of minimum-delay packet. This delay is an absolute delay and is the difference between the instant of receiving the packet and the instant of transmitting the packet the latter being obtained from the time-stamp embedded in the packet. As an example, the RTP protocol allows such a time-stamp.
- T = packetization delay or the fixed gap between successive data packet transmissions within a call. T is a constant for all calls of a given class but may be different for different classes.
- ta = actual arrival instant of a data packet
- tr = t0 + s*T = Reference zero-delay arrival instant of a data packet where s is the sequence number of the packet minus the sequence number of the minimum-delay packet.
- Delay = ta - tr. So this delay is a relative delay. It is positive if ta > tr and negative if ta < tr.
- m = small fractional increase in the minimum-delay if the data packet arrives later than its reference zero-delay arrival instant.
- max = Maximum allowed value of ideal_depth as well as realized_depth of de-jitter buffer. Both of the depth parameters represent the amount (ideal or realized) of de-jitter buffer delay experienced by a data packet that arrives exactly at its reference zero-delay arrival instant. If a newly arriving data packet is too early to force the realized_depth to exceed max then the data packet is dropped due to buffer overflow.

Figure 8

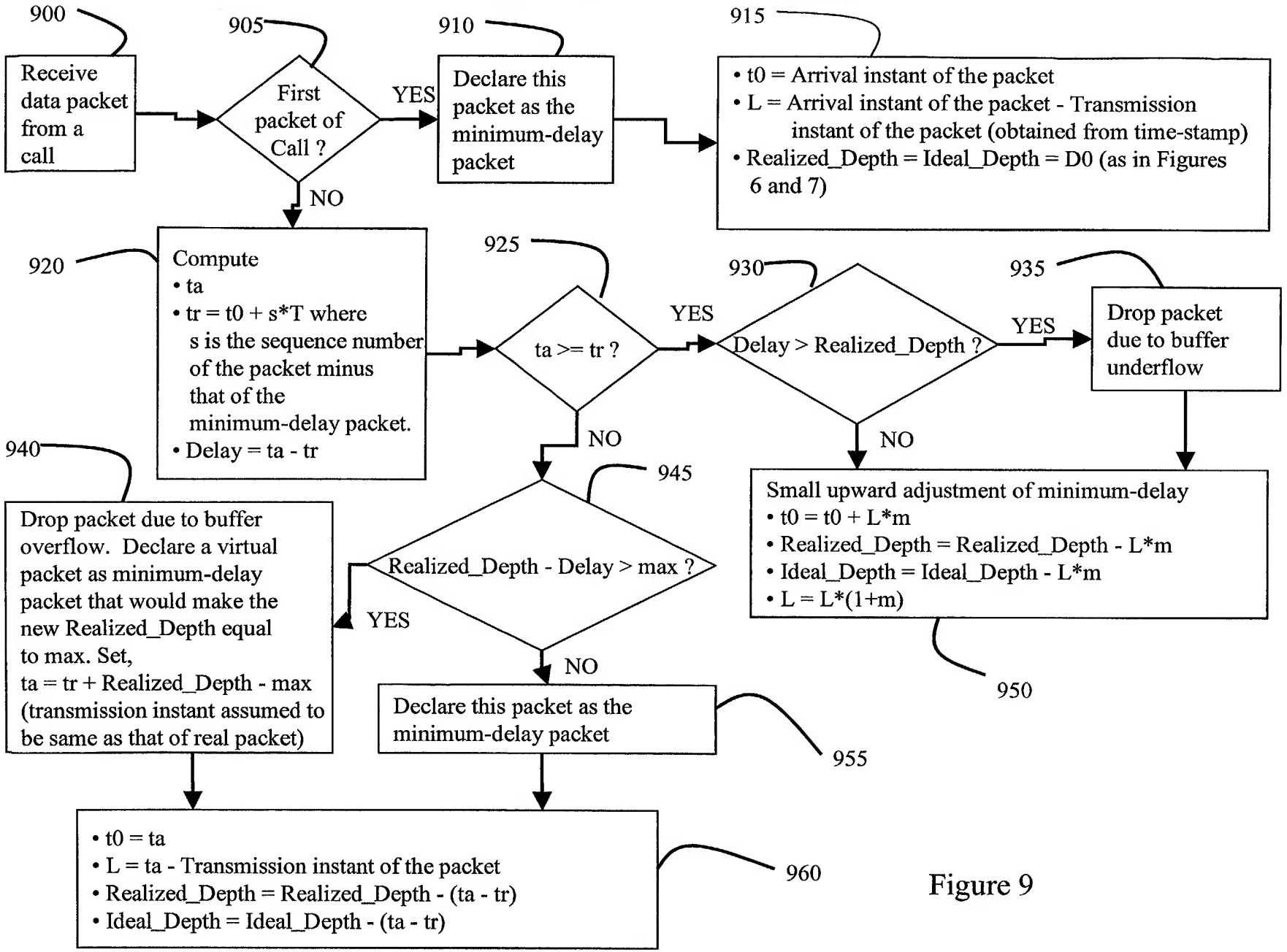
900
Receive data packet from a call
905
First packet of Call ?
YES
NO
910
Declare this packet as the minimum-delay packet
915
• t0 = Arrival instant of the packet
• L = Arrival instant of the packet - Transmission instant of the packet (obtained from time-stamp)
• Realized_Depth = Ideal_Depth = D0 (as in Figures 6 and 7)
920
Compute
• ta
• tr = t0 + s*T where s is the sequence number of the packet minus that of the minimum-delay packet.
• Delay = ta - tr
925
ta >= tr ?
YES
NO
930
Delay > Realized_Depth ?
YES
NO
935
Drop packet due to buffer underflow
940
Drop packet due to buffer overflow. Declare a virtual packet as minimum-delay packet that would make the new Realized_Depth equal to max. Set,
ta = tr + Realized_Depth - max
(transmission instant assumed to be same as that of real packet)
945
Realized_Depth - Delay > max ?
YES
NO
Small upward adjustment of minimum-delay
• t0 = t0 + L*m
• Realized_Depth = Realized_Depth - L*m
• Ideal_Depth = Ideal_Depth - L*m
• L = L*(1+m)
950
Declare this packet as the minimum-delay packet
955
• t0 = ta
• L = ta - Transmission instant of the packet
• Realized_Depth = Realized_Depth - (ta - tr)
• Ideal_Depth = Ideal_Depth - (ta - tr)
960

Figure 9